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Poster paper

The controller for Shanghai Synchrotron Radiation Facility in-vacuum undulators

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The in-vacuum undulator (IVU) controller has been developed and applied in Shanghai Synchrotron Radiation Facility (SSRF), China. The controller based on programmable logic controller (PLC) mainly controls two stepper motors for regulating the gap and taper of magnet array, implement automatic control of the correction coil power supplies, etc. In addition, the controller is also provided with a local and remote working mode. This paper mainly introduces related hardware and software design for the IVU controller.

1. Introduction

Shanghai Synchrotron Radiation Facility (SSRF), a third-generation light source in China, is currently in the routine operation stage for nearly 1 year. There are five insertion devices for SSRF phase-I, including two in-vacuum undulators (IVUs) (IVU25), one Elliptically Polarizing Undulator (EPU) (EPU10) and two wigglers (W80 and W140) (Dai *et al.* 2008). Figure 1 is the IVU installed in a storage ring for hard X-ray microfocus beamline (BL15U1).

2. Architecture

The IVU controller cabinet layout is showed in figure 2. Two stepper motors are adopted to drive, respectively, two gear reducers and screw systems, whose drivers can give rotary monitor signals from which PLC judges whether stepper motor responded correctly to pulses sent by the stepper controller. In addition, the stepper motors are equipped with the brake system used as motion safety protection. Besides local interface via multi-point interface, the controller is also provided with remote interface via Ethernet.

3. Position feedback control

Position feedback is derived from four linear absolute encoders (LAEs), which possess synchronous serial interfaces, through which PLC's SM338 module can

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FIGURE 1. The IVU25 installed in a storage ring.

acquire the real-time and high-precision position information. Four LAEs, respectively, measure the positions of two sides of top and bottom outer girders.

The undulator controller based on SIEMENS S7-300 PLC has such fast scanning speed that it can take advantage of close-loop control technology to achieve $\pm 1 \mu\text{m}$ position precision. The position feedback control process is illustrated in figure 3.

4. Safety protection

In addition to accurate motion control, the controller must ensure stable and reliable operation of the IVU. Especially much importance must be attached to safety protection of machine motion. Faulty machine motion would result in permanent machine damage. Mechanical hard stop, kill switches and photo-interrupter limit switches are used to implement minimum and maximum gap protection. Allowing for reliable and flexible operation, the opposite direction of all safety protections is permitted based on authorization.

5. Correction coil power supply control

The correction coil power supply (CCPS) control consists of two control modes. One is the direct control mode (direct output current according to user setting value) and the other is the automatic control mode (automatically output current according to the real-time gap position). The CCPS currents consist of vertical current and horizontal current. The vertical current range is $\pm 2 \text{ A}$ and the horizontal current range is $\pm 3 \text{ A}$. The AD/DA modules for CCPS control possess a 16-bit resolution.

6. Software design

Software designs are composed of two parts, one is a program design based on PLC, and the other is a program design based on the experimental physics and industrial control system (EPICS).

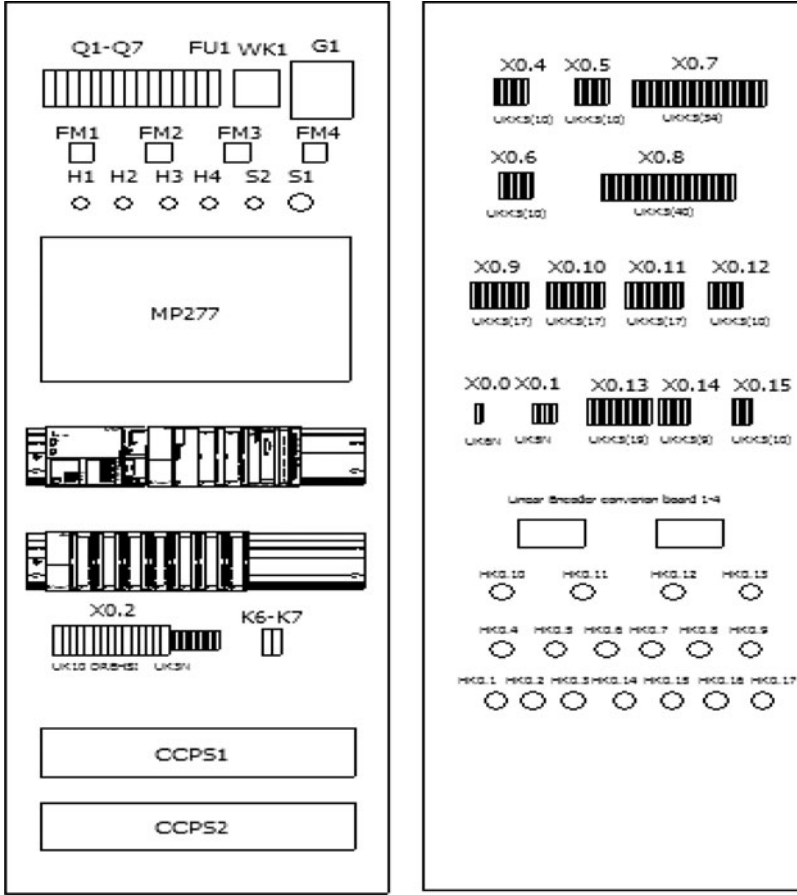


FIGURE 2. The front and rear view of the IUV controller cabinet.

PLC program design environments are SIEMENS Step 7 and WinCC Flexible 2007. According to the actual application, PLC's task modules mainly consist of motion control, LAEs reading, temperature and flux monitor, safety protection, communication with EPICS, etc. Figure 4 is the main interface of Human Machine Interface (HMI) in the local mode.

The communication between soft input and output controller (IOC) and PLC is via Ethernet TCP/IP. To make EPICS save the last running statuses and parameters after IOC restarting, the autosave module is applied in the S7plc driver packages.

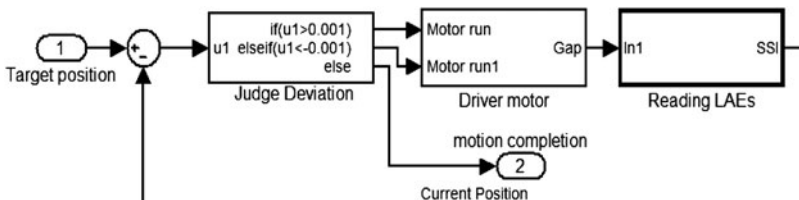


FIGURE 3. The position feedback control process.

PLS In-Vacuum Undulator IVU20 Controller

Gap-CC_Current Table 11/11/2008 10:59:58 AM

Index	Gap (mm)		Iuh (A)		Iuv (A)		Idh (A)		Idv (A)	
	Set	Readback	Set	Readback	Set	Readback	Set	Readback	Set	Readback
0	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
1	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
2	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
3	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
4	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
5	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
6	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
7	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
8	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
9	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
10	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
11	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
12	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
13	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
14	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
15	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
16	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
17	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
18	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000
19	00.000	00.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000

Buttons: Main, Maintain, Gap Limit & Water, Magnet Pole Temperature, Correction Coil Table, Error Info.

FIGURE 4. Main interface of HMI in the local mode.

7. Conclusions

The IVU25 has been in routine operation for nearly about 1 year since April 2009. The IVU25 maintains reliable operation during the commissioning stage and routine operation stage, up to a certain extent as is ascribed to a reliable IVU controller design and fabrication.

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